STUDIES ON BOREAL AGROMYZIDAE (DIPTERA). I.
PHYTOMYZA MINERS ON SAXIFRAGACEAE

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Five species of Phytomyza *are known as leaf-miners of Saxifragaceae. Three of these are confined to* Saxifraga, *as follows:* Phytomyza deirdreae *n. sp. (Western Canada, Alaska and Japan, type-locality Sitka),* P. saxifragae *Hering (Central Europe and Balkans) and* P. aizoon *Hering (Central Europe). On other genera of Saxifragaceae two new species are recorded:* Phytomyza tiarellae *n. sp. on* Tiarella *and* Tolmiea *(type-locality Sitka, Alaska) and* P. mitellae *n. sp. on* Mitella *(type-locality Edmonton, Alberta).*

Cinq espèces de Phytomyza *sont connues comme mineuses dans les feuilles des Saxifragacées. Trois de ces espèces sont limitées à la* Saxifraga, *tel que:* Phytomyza deirdreae *n. sp. (L'ouest du Canada, Alaska et Japon, localité-type Sitka),* P. saxifragae *Hering (Europe centrale et Balkans) et* P. aizoon *Hering (Europe centrale). Sur les autres genres de Saxifragacées deux espèces nouvelles sont rapportées:* Phytomyza tiarellae *n. sp. sur* Tiarella *et sur* Tolmiea *(localité-type Sitka, Alaska) et* P. mitellae *n. sp. sur* Mitella *(localité-type Edmonton, Alberta).*

Fünf Phytomyza-*Arten sind als Blattminierer von Saxifragaceae bekannt. Drei von diesen sind auf* Saxifraga *beschränkt, wie folgt:* Phytomyza deirdreae *n. sp. (Westlich Kanada, Alaska und Japan, Fundort vom Typus Sitka),* P. saxifragae *Hering (Mitteleuropa und Balkanhalbinsel) und* P. aizoon *Hering (Mitteleuropa). An anderen Saxifragaceen-Gattungen werden zwei neue Arten besprochen:* Phytomyza tiarellae *n. sp. an* Tiarella *und an* Tolmiea *(Fundort vom Typus Sitka, Alaska) und* P. mitellae *n. sp. an* Mitella *(Fundort vom Typus Edmonton, Alberta).*

The present paper is the first of a series dealing with boreal and arctic Agromyzidae, both from the Palaearctic and Nearctic regions. The distinction between these regions becomes unnatural at the level of the boreal forest, because many of the species found here are distributed in both regions or have their closest relatives in the other region. I will be particularly concerned in this series with making critical comparisons between European and North American material, in order to establish which species are holarctic. The Agromyzidae are well suited for studies of historical biogeography, because their restricted choice of larval host-plants allows hypotheses about their dispersal to be correlated with the likely dispersal of their host-plants.

The references listed in this series with the synonyms of each species will refer only to works which contain nomenclatural proposals or present substantial new information on the species. References in catalogues, faunal lists and summarizing works will not be listed in synonymies unless meeting the above criteria.

In the present paper I deal with the miners of Saxifragaceae *sensu stricto*. I do not treat the miners of the Hydrangeaceae (including *Philadelphus, Deutzia* and *Hydrangea*), which are included in Saxifragaceae in some botanical classifications. Names of plants are used in the sense of Webb (1964) for European species, and of Hultén (1968) for North American species.

The holotypes of the new species described in this paper will be deposited in the Canadian National Collection (Ottawa). Other North American material is in the University of Alberta collections and in my personal collection. Leaf mines of the North American species are preserved in my herbarium of mines.

TERMS APPLIED TO MALE GENITALIA

I have discussed elsewhere (Griffiths, in press) the terms applied to the male postabdomen and genitalia of cyclorrhaphous Diptera in general. The proposals in that book entail modifications of the terms in use for some parts of the male genitalia of Agromyzidae. Table 1 sets out the terms used in the present series of papers, with the equivalent term or terms used in recent literature on Agromyzidae.

Table 1. Equivalence of terminology.

Equivalent previous terminology	Revised terms
Areas of aedeagus	
basal section (basiphallus) and phallophore	basal section
distal and median sections	distal section
hypophallus	medial lobe(s)
Sclerites of aedeagus	
arms of basiphallus, or sclerites of basiphallus	basal sclerites or paraphalli
paraphalli	paramesophalli
sclerites of hypophallus	sclerites of medial lobe(s)
(The application of the terms phallophore, distiphallus and mesophallus is unchanged.)	
Other parts of genital segment	
epandrium	periandrium
surstyli	telomeres
(The application of the terms epiphallus, aedeagal hood, hypandrium, pregonites and postgonites is unchanged.)	

I now consider the narrow dorsal band of sclerotization found after the 6th tergum in some agromyzid species as a remnant of the inverted 8th sternum (a large sclerite in many other families of Schizophora).

A special difficulty already recognized by other authors (Nowakowski, 1964; von Tschirnhaus, 1969) involves the application of the terms "dorsal" and "ventral" to the aedeagus. In Agromyzidae and many other families of Schizophora, the aedeagus is swung by muscular action through a wide arc from a posteriorly directed copulatory position to an anteriorly directed rest position (Griffiths, in press). Which side of the aedeagus is dorsal and which ventral thus depends on the position of the organ. The convention in descriptions of Agro-

myzidae is to apply these terms with reference to the rest position of the aedeagus. Probably little would be gained by attempting to change this convention. But the ambiguity of these terms should be appreciated. In discussions where an equivalent application of such terms as "dorsal" and "ventral" throughout the Diptera is needed these terms should be applied to the copulatory position of the aedeagus in those groups of Schizophora which show the swinging mechanism.

ABBREVIATIONS

The following conventional abbreviations are used in descriptions:

acr	acrostichal setulae
dc	dorsocentral bristle(s)
ia	intra-alar setulae
mg_2, mg_3, mg_4	second, third and fourth costal sections
ori	lower orbital bristle(s)
ors	upper orbital bristle(s)
pa	postalar bristle(s)

RELATIONSHIPS OF SPECIES TREATED

In my discussion of the *Phytomyza syngenesiae* group (Griffiths, 1967) I alluded to the possibility of defining as one of the segregates of *Phytomyza* in the present sense a group containing the *syngenesiae* group, the *milii* group and *P. nigra* Meigen. The species now treated in this paper, as well as some of the *Phytomyza* miners of Gentianaceae and Caprifoliaceae, may be added to this list. Hardy's (1849) name *Chromatomyia* may be applied to this group (whether as genus or subgenus), when a division of *Phytomyza* in the present wide sense is proposed (see Griffiths, 1967). But such a formal proposal would be premature at the present time, as the male genitalia of many European species have still not been described. The structure of the distal section of the aedeagus in this group is strongly modified (apomorphous). Most characteristic is the presence of a pair of dorsal "supporting sclerites", arising from the base of the distal section (Fig. 8). I accept von Tschirnhaus' (1969) opinion that these sclerites should not be called the "distiphallus" (as in my 1967 paper), and follow him in calling them supporting sclerites ("Stützsklerite"). The medial lobe ("hypophallus") is poorly or not at all differentiated. And it is doubtful whether a true distiphallus (containing a bifid terminal portion of the ejaculatory duct) is retained in any members of this group. Von Tschirnhaus uses the term distiphallus for the distal tubule containing the ejaculatory duct in the *syngenesiae* group; but since this is unpaired it more probably represents the mesophallus (as assumed in my 1967 paper) or a secondary sclerotization.

All species with the type of aedeagus described above also show a characteristic apomorphous type of puparium. The puparium remains within the host plant, with its anterior spiracles bent downwards so that they project through the epidermis. Hardy (1849) characterized his proposed genus *Chromatomyia* on the basis of this puparium type. However this puparium type has a wider distribution than the type of aedeagus described above. Either the apomorphous puparium type indicates a wider monophyletic group inclusive of the group characterized by the apomorphous type of aedeagus; or the puparium type has evolved more than once. The latter possibility cannot be evaluated without studies of additional groups of species. But I am confident that the species which show both the modified form of aedeagus and the *Chromatomyia*-type of puparium form a monophyletic group, deserving eventually of nomenclatural recognition.

DIAGNOSIS

The species treated in this paper can be identified most readily as larvae or puparia. The three species on *Saxifraga* show obvious differences in the form of the posterior larval (and puparial) spiracles (Fig. 3-5). In the new species *tiarellae* (on *Tiarella* and *Tolmiea*) and *mitellae* (on *Mitella*) these spiracles have a characteristic crescentic form (Fig. 6-7). No other agromyzid larvae are known to mine the leaves of Saxifragaceae.

Caught males of these species can be identified by study of their genitalia, particularly the form of the distal section of the aedeagus. I am doubtful whether reliable diagnosis is possible on the basis of the external form of the adult.

The three new species may be included in Spencer's (1969:219) key to *Phytomyza* species of Canada and Alaska by the following extensions.

56.	Sides of thorax bright yellow	*notopleuralis* Spencer
–	Sides of thorax predominantly dark	56a
56a.	Aedeagus as in Spencer's Fig. 395, with membranous distal section	*agromyzina* Meigen
–	Aedeagus as in Figs. 13 and 15-17	56b
56b.	Mesonotum strongly shining; aedeagus as in Fig. 13	*mitellae* n. sp.
–	Mesonotum weakly shining; aedeagus as in Fig. 17	*tiarellae* n. sp.

58.	Distal section of aedeagus with cylindrical mesophallus and distiphallus consisting of divergent tubules (Spencer's Fig. 442)	*ilicis* Curtis
–	Aedeagus not of this type	59
59.	Aedeagus as in Spencer's Figs. 447-448	*involucratae* Spencer
–	Aedeagus as in Spencer's Fig. 460	*milii* Kaltenbach
–	Aedeagus as in Figs. 8-9	*deirdreae* n. sp.

TREATMENT OF SPECIES

Phytomyza deirdreae new species

"*Phytomyza saxifragae* Hering". Sasakawa, 1956:105. –1961:467.

Adult. – Head (Fig. 2) with orbits not or only very narrowly projecting above eyes in lateral view; genae in middle about ¼ of eye height; eye pubescence fine and inconspicuous. Frons at level of front ocellus about twice width of eye. Two ors, of equal length, posteriorly directed; two ori, inwardly directed, anterior at least half as long as posterior; orbital setulae one-rowed. Peristomal margin with vibrissa and 6-8 upcurved peristomal setulae. Third antennal article rounded distally, with only short pubescence.

3 + 1 dc; acr numerous, in 5-7 rows anteriorly, 4-5 rowed posteriorly; presutural ia numerous; 11-16 postsutural ia; inner pa long, over half as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 2.9-3.1 in type series (about 3.5 in Japanese material according to Sasakawa, 1956). Wing length about 2.5 mm (both sexes).

Colour largely dark. Centre of frons dark brown, only slightly paler than black orbits and ocellar plate; genae dark brown. Antennae black. Palpi black; labella brown or yellow-brown. Thorax finely grey-dusted, only weakly shining, completely black except whitish seams of notopleural and mesopleural sutures; squamal margin and fringe infuscated; wing base infuscated. Legs dark, with tips of femora yellow-brown (but only those of front legs

distinctly so). Basal cone of ovipositor (♀) dusted on about basal two-thirds.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres not delimited from periandrium, indicated by dense group of short setulae. Aedeagus as in Fig. 8-9, with large ventral area enclosed by membrane, without medial lobe; supporting sclerites fused basally, in form of Y-shaped structure with base confluent with short stretch of sclerotization of ejaculatory duct; other distal sclerites (? mesophallus or paramesophalli) better developed than in *saxifragae* and *aizoon*, extending anteriorly below supporting sclerites. Ejaculatory apodeme (Fig. 10) very small.

Additional figures and information on the female genitalia (not considered here) are given by Sasakawa (1961).

Puparium and third instar larva. – Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles two-horned, with at least 25 bulbs. Posterior spiracles (Fig. 3) with about 40-45 bulbs, with two very long and slender horns which are directed more or less vertically on puparium. Colour of puparium variable (white, brown or blackish). Length of puparium 2.3-2.5 mm.

Other figures are given by Sasakawa (1961).

Mine. – Larvae leaf-miners on certain *Saxifraga* species (see records below). Mine (Fig. 22) at origin with short linear channel, but soon broadened into irregular blotch (the latter in some cases enclosing the initial linear channel), appearing white or greenish white in incident light; faeces scattered as discrete particles throughout mine; main part of mine normally formed on upper surface of leaf, with pupation following at end of short channel without faeces on lower surface (but a few mines formed entirely on the lower surface were also found). Puparium with its ventral surface adjacent to surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Types. – Holotype ♂, 3 ♀♀ paratypes from larvae and puparia 19.viii.69 on *Saxifraga ferruginea* Graham, Harbour Mountain (1900 feet elevation), Sitka, Alaska, emerged 1.ix.69, 2.ix.69, 5.v.70 (holotype) and 6.v.70, leg. D. E. and G. C. D. Griffiths.

Additional records. – I hope to obtain further material from larvae and puparia collected 15-23.viii.71 on *Saxifraga lyallii* Engler, *S. nivalis* L. and *S. punctata* L. on the slopes above the Mount Cavell chalet, Jasper National Park, Alberta, at elevations between 5900 and 7900 feet.

Additional records for North America, based on my own collections of larvae and puparia which yielded parasites, are as follows:

Puparia 20.viii.69 on *Saxifraga punctata* L., same locality as type series (1000 feet elevation); puparia 27.viii.69 on *Saxifraga punctata* L., Chilkat Pass (3000 feet elevation), Haines highway, British Columbia; larvae and puparia 17-19.vii.68 on *Saxifraga hieracifolia* Waldst. and Kit. and *S. punctata* L., Eagle Summit (3900 feet elevation), Steese highway, Alaska.

Sasakawa (1956) described material bred from *Saxifraga sachalinensis* Fr. Schm., Jyôzankei, Hokkaido, Japan (leg. Y. Nishijima). In his 1961 work he also records this species on *S. fusca* Maxim., Mount Hakusan, Toyama Prefecture (Japan).

Dedication. – I am pleased to dedicate this species to my wife Deirdre, who has assisted me ably on field work.

Discussion. – The description of this species brings the total of known *Phytomyza* miners of *Saxifraga* to three. The other two species (*saxifragae* and *aizoon*) are known only from Europe. The three species are probably monophyletic, as evidenced by the similar form of the aedeagus. The most obvious differences between them are in the form of the posterior larval (and puparial) spiracles (Fig. 3-5). There are also slight differences in the form of the distal section of the aedeagus. There are probably some statistical differences in the external

form of the adult, for instance in the costal ratio and numbers of thoracic setulae; but the available material of all species is too limited for reliable statistical treatment.

The occurrence of *Phytomyza* miners on *Saxifraga* in Finland is indicated by Linnaniemi's (1913, Fig. 29) photograph of mines on *Saxifraga nivalis* L. I think these mines may well be those of *deirdreae*, but no firm opinion can be given in the absence of information on the form of the puparia. Hering (1957) includes Linnaniemi's record as no. 4648 in his key to miners of *Saxifraga*.

I regard the Japanese material described by Sasakawa (1956, 1961) as probably conspecific with my North American material, not with the Central European species *Phytomyza saxifragae* Hering. Sasakawa's (1961) Fig. 143n indicates long and slender horns on the posterior larval spiracles, and his figure of the aedeagus (143d) also agrees substantially with that of the holotype of *deirdreae*. I detect a discrepancy only in his figure (143c) of the telomeres ("surstyli"). The group of short spines indicated by Sasakawa are represented by rather longer setulae in the holotype.

The known distribution of *Phytomyza deirdreae* is indicated on Fig. 19.

Phytomyza saxifragae Hering 1924

Phytomyza saxifragae Hering. Hering, 1924:38. –1927:135. De Meijere, 1926:289. –1941: 25. Hendel, 1928:99. –1935:473. Holotype ♀, Herculesbad (Roumania), in the Zoologisches Museum, Humboldt Universität, Berlin.

Adult. – Hendel (1935) has described the external form of the adult in detail. I am unable to separate this species from *deirdreae* on external characters. The costal ratio mg_2/mg_4 is 3.3-3.5 in the specimens I examined. The sclerites of the wing base are paler than in *deirdreae*, but Hendel's (1935) description "Flügelwurzel weisslichgelb, kontrastierend" seems exaggerated. The colour difference is not so great that I would rely on it for identification.

Male postabdomen and genitalia similar to those of *deirdreae*, but with some difference in form of distal section of aedeagus (Fig. 11); base of supporting sclerites not confluent with short stretch of sclerotization of ejaculatory duct; area below supporting sclerites membranous.

Puparium and third instar larva. – Differing from *deirdreae* in form of posterior spiracles, which have 22-25 bulbs in a widely open bow (Fig. 5), with only one prominent horn which is directed more or less horizontally on puparium. See further the descriptions and figures of de Meijere (1926, 1941). Puparium black ventrally, red dorsally (Hering, 1927).

Mine. – Larvae leaf-miners on *Saxifraga rotundifolia* L. Mine (Fig. 23) primarily linear according to Hering (1924, 1927) and Hendel (1928, 1935), but seldom extended, usually crossing itself or blending to form secondary blotch, appearing whitish in incident light. Hendel gives the length of the mine as about 14 cm, and its greatest terminal width as 2.75-3.0 mm. Faeces scattered as discrete particles on either side of mine channel (separated by about 5 mm in terminal part of mine). Main part of mine normally formed on upper surface of leaf (but sometimes on lower surface according to Hering), with pupation normally following on lower surface. Puparium (when internal) with its ventral surface adjacent to surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Hering (1924, 1927) stated that puparia were found inside the leaf, which I think must be their normal location in view of their morphological adaptation to this end (anterior spiracles turned downwards). However Hendel (1928) reported that larvae may also leave the leaf to pupate.

A photograph of the leaf mine is given by Hendel (1928, Tafel V).

Material examined. – 1 ♀ from mine on *Saxifraga rotundifolia* L., West Rila mountains,

Bulgaria, emerged 31.viii.39, leg. H. Buhr. 1 ♂ from mine on *Saxifraga rotundifolia* L., Vals, Switzerland, emerged 8.vii.29, leg. W. Hopp. 1 ♂ from mine on *Saxifraga rotundifolia* L., Rigi, Switzerland, emerged 2.viii.25, leg. M. Hering.

Additional records. – This species was originally described from Herculesbad in the Banat region of Roumania (Hering, 1924) (holotype ♀ emerged 30.v.22 from puparium collected 13. v.22). Hering also refers in that paper to the finding of mines at Königssee, near Berchtesgaden in Bavaria (Germany). There are also sheets in Hering's mine herbarium (now in the British Museum) for the Plöckenpass, Carinthia (Austria), 27.vi.29, leg. Hedicke; and for Brunnsteinsee, Warscheneck-Gebirge, Austria (1600 metres elevation), 28.viii.60, leg. E. M. Hering.

Discussion. – The above records indicate that this species is widely distributed at high elevations in the mountains of central Europe and the Balkans (Fig. 20). Buhr (reported by de Meijere, 1941) gives its altitudinal range in the West Rila mountains as 1600 to 2200 metres. Webb (1964) indicates that the host-plant is widely distributed in the mountains of central and southern Europe, but does not occur in northern Europe.

Phytomyza aizoon Hering 1932

Phytomyza aizoon Hering. Hering, 1932:162. Hendel, 1934:337. De Meijere, 1938:87. Syntypes ♂ ♀, Mauthen (Carinthia, Austria), in the Zoologisches Museum, Humboldt Universität, Berlin.

Adult. – Hering (1932) and Hendel (1934) have described the external form of the adult in detail. Adults of this species are substantially similar on external characters to those of the previous two species (*saxifragae* and *deirdreae*), but I note the following points. According to Hendel the orbits in *aizoon* are distinctly projecting above the eye in lateral view (his Fig. 345), and the arista is thickened to about its middle (only on about its basal third in the other two species). 8-11 postsutural ia. The costal ratio mg_2/mg_4 is only 2.4 in the paratype examined by me; the value 3.0 in the original description (Hering, 1932) is probably an overestimate, as already implied by Hendel's (1935) placement of *aizoon* in his key (p. 511). Size smaller (wing length about 1.75 mm).

Male postabdomen and genitalia similar to those of *deirdreae* and *saxifragae*, but with some difference in form of distal section of aedeagus (Fig. 12); base of supporting sclerites not confluent with short stretch of sclerotization of ejaculatory duct; area below supporting sclerites membranous, not extending so far anteriorly as in *saxifragae*.

Puparium and third instar larva. – Differing very obviously from *saxifragae* and *deirdreae* in form of spiracles. Anterior spiracles knob-shaped, with only 9-10 bulbs (Hering, 1932). Posterior spiracles (Fig. 4) small, knob-shaped, with only 9-12 bulbs. Puparium white, 2.3 mm long.

Mine. – Larvae leaf-miners on *Saxifraga paniculata* Miller (= *aizoon* Jacq.). Hering (1932, 1957) describes the mine as a gradually widening upper-surface channel, sometimes branching, often becoming blotch-like terminally; appearing greenish or brownish in incident light; with mine channel sometimes becoming swollen subsequently due to formation of callus tissue; faecal particles present. Puparium remaining in mine, with its ventral surface adjacent to surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Material examined. – 1 ♂ paratype from mine 24.vii.29 on *Saxifraga paniculata* Miller, Mauthen, Carinthia, Austria, emerged 3.viii.29, leg. O. Hering.

Additional records. – Hering (1932) records this species for Mauthen (Carinthia, Austria) and Zernez, Switzerland (adult emerged 16.viii.29 from mines collected 12.vii.29, leg. Hopp). The only additional collection which I have traced is by Zavřel on 12.ix.52 at Berg Kotouč, Stramberg, Eastern Moravia (Czechoslovakia) (sheet in Hering's mine herbarium).

Discussion. – The above records suggest a restricted distribution for this species in the mountains of central Europe (Fig. 21), where it is sympatric with *saxifragae*. But the real distribution may well be much wider, for Webb (1964) indicates that the host-plant is widely distributed also in southern Europe, Asia Minor and the Caucasus, and occurs locally in Norway. A "variety" of the host-plant occurs in North America (mainly in the East), but has not yet been examined for leaf miners.

Phytomyza tiarellae new species

Adult. – Head (compare Fig. 1) with proportionately large eyes; orbits not projecting above eyes in lateral view; genae in middle less than ¼ of eye height; eye pubescence fine and inconspicuous. Frons at level of front ocellus about twice width of eye. Two ors, of equal length, posteriorly directed; two ori, inwardly directed, anterior pair variable in length (only slightly shorter than posterior pair in holotype, but less than half as long in paratype); orbital setulae one-rowed. Peristomal margin with vibrissa and 5-6 upcurved peristomal setulae. Third antennal article rounded distally, slightly longer than high, with fairly long pale pubescence.

3 + 1 dc; acr numerous, in 5-6 rows anteriorly, becoming 4-5 rowed posteriorly; presutural ia numerous; 6-10 postsutural ia; inner pa about half as long as outer pa.

Second cross-vein (m-m) absent. Costal ratio mg_2/mg_4 3.0 in male holotype, 3.5 in female paratype. Wing length 2.1 mm (holotype), 2.5 mm (paratype).

Colour largely dark. Centre of frons partly brown (paler than black orbits and ocellar plate); genae brown. Antennae black. Palpi black; labella yellow. Thorax finely grey-dusted, only weakly shining, completely black except whitish seams of sutures (especially notopleural and mesopleural sutures); squamal margin and fringe infuscated, but wing base contrastingly whitish. Legs with coxae, trochanters and femora largely dark, but with tips of femora and whole of tibiae and tarsi contrastingly deep yellow or yellow-brown. Abdomen largely dark brown. Basal cone of ovipositor (♀) dusted on about basal two-thirds.

Male postabdomen with 8th sternum fused with 6th tergum. Telomeres not delimited from periandrium, indicated by dense group of short setulae. Aedeagus as in Fig. 15-17, with medial lobe weakly differentiated; supporting sclerites closely approximated, parallel; small membranous lobe present distal to supporting sclerites; sclerites below supporting sclerites (? paramesophalli) appearing broad basally in lateral view, extending distally almost as far as supporting sclerites. Ejaculatory apodeme (Fig. 18) very small.

Puparium and third instar larva. – Mandibles with two alternating teeth; right mandible longer than left. Anterior spiracles two-horned, with about 20 bulbs. Posterior spiracles (Fig. 6) one-horned, with 18-23 bulbs arranged more or less in crescent. Puparium brown or white, with darker strip on ventral surface. Length of puparium 1.9-2.1 mm.

Mine. – Larvae leaf-miners on *Tiarella trifoliata* L. and *Tolmiea menziesii* (Pursh). Mine (Fig. 24) entirely linear, appearing white in incident light, up to 20-25 cm long, about 2 mm wide terminally; faeces scattered as discrete particles (mostly separated by over 1 mm), or forming short "threads" (Fadenstücke) in terminal part of mine; mine formed entirely on upper surface of leaf, but with puparium formation following on lower surface at end of mine channel. Puparium with its ventral surface adjacent to surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Types. – Holotype ♂, 1 ♀ paratype from larvae and puparia 22-24.viii.69 on *Tiarella trifoliata* L., Starrigavan, Sitka, Alaska (near sea level), emerged 9.ix.69 and 8.v.70 (holotype), leg. G. C. D. Griffiths.

Discussion. – Puparia were also collected at the type locality on *Tolmiea menziesii*

(Pursh), but only parasites obtained from this sample.

The known host-plants of *tiarellae* are both distributed mainly in the rain forest of the Pacific coast of North America, with ranges from Alaska to northern California (Hultén, 1968). A similarly restricted distribution may also be expected for the fly. The mean annual rainfall at the type locality is probably about 100 inches, on the basis of data for the Sitka Magnetic weather station.

The emergence of one of the adult flies soon after collection of the puparia indicates that this species is at least partly multivoltine, unlike the species next to be described.

Phytomyza mitellae new species

Adult. – External form of adult as described for *tiarellae*, except as follows. Frons about 1.5 times eye width at level of front ocellus. Anterior pair of ori well developed in all specimens, at least half as long as posterior pair (Fig. 1). Costal ratio mg_2/mg_4 2.4 in male holotype, 2.7-3.0 in female paratypes. Wing length 1.9-2.2 mm. Ocelli bright red in most specimens, but yellow in two females (as normally in *Phytomyza*, including all other species treated in this paper). Mesonotum strongly shining, with only very fine dusting; sides of mesonotum brown; mesopleuron with dorsal and posterior margins narrowly white; squamae pale, with only their fringe infuscated. Abdomen brown, in some specimens yellowish on sides at base.

Male postabdomen and genitalia very similar to those of *tiarellae*, but with some difference in form of distal section of aedeagus (Fig. 13); sclerites below supporting sclerites (? paramesophalli) appearing narrower in lateral view, not extending so far distally (with their apices well short of apices of supporting sclerites).

Puparium and third instar larva. – Very similar to *tiarellae*; posterior spiracles (Fig. 7) one-horned, with 14-17 bulbs arranged more or less in crescent. Puparium uniformly brown or yellow-brown. Length of puparium 1.7-2.1 mm.

Mine. – Larvae leaf-miners on *Mitella nuda* L. Mine (Fig. 25) entirely linear, appearing white in incident light, 10-11 cm long, 1.5-2.0 mm wide terminally; faeces deposited as fine particles, forming more or less continuous strip in early part of mine, separated (but mostly by less than 1 mm) in terminal part of mine; mine formed entirely on upper surface of leaf, but with puparium formation following on lower surface at end of mine channel. Puparium with its ventral surface adjacent to surface of leaf, with its anterior spiracles projecting ventrally through epidermis.

Types. – Holotype ♂, 6 ♀♀ paratypes from larvae and puparia 21.viii-27.ix.70 on *Mitella nuda* L., Edmonton (White Mud Creek and north-facing slopes of river valley), Alberta, emerged 14-26.v.71 (holotype 14.v.71), leg. D. C. Christophel, V. K. Sehgal, D. E. and G. C. D. Griffiths.

Additional records. – This species also occurs at Elk Island National Park, Alberta (mines with larvae noted on 21.ix.71).

Discussion. – The host plant is common in the ground layer of forest in the Edmonton district. It is one of the few herbs whose leaves remain green through the winter beneath the snow cover. The fly seems to be univoltine, since no mines have been found before late August. Feeding larvae continued to be found up to September 27th, the last pupating in the insectary on October 1st. This is well after leaf fall and the onset of frost.

I have no doubt that *mitellae* and *tiarellae* are monophyletic; for instance, the crescentic form of the hind spiracles of the puparium and the presence on the male aedeagus of a membranous lobe distal to the supporting sclerites, are both synapomorphous characters of these two species.

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REFERENCES

Griffiths, G. C. D. 1967. Revision of the *Phytomyza syngenesiae* group (Diptera, Agromyzidae), including species hitherto known as "*Phytomyza atricornis* Meigen". Stuttg. Beitr. Naturk. no. 177. 28 pp.

Griffiths, G. C. D. in press. Studies on the phylogenetic classification of Diptera Cyclorrhapha, with special reference to the structure of the male postabdomen. Uitgeverij Dr. W. Junk, The Hague.

Hardy, J. 1849. On the primrose-leaf miner, with notice of a proposed new genus, and characters of three species of Diptera. Ann. Mag. nat. Hist. 4:385-392.

Hendel, F. 1928. Blattminenkunde Europas. I. Die Dipterenminen 2. Fritz Wagner, Vienna: 65-100.

Hendel, F. 1931-1936. Agromyzidae. Fliegen palaearkt. Reg. 6(2), Teil 59. 570 pp.

Hering, M. 1924. Zur Kenntnis der Blattminenfauna des Banats. I. Z. wiss. InsektBiol. 19:1-15, 31-41.

Hering, M. 1927. Agromyzidae. Tierwelt Dtl. 6. 172 pp.

Hering, M. 1932. Minenstudien 11. Z. wiss. InsektBiol. 26:157-182.

Hering, E. M. 1957. Bestimmungstabellen der Blattminen von Europa einschliesslich des Mittelmeerbeckens und der Kanarischen Inseln. Uitgeverij Dr. W. Junk, The Hague. 1185 + 86 pp. (3 vols.).

Hultén, E. 1968. Flora of Alaska and neighbouring territories. Stanford University Press, Stanford, California. xxii + 1008 pp.

Linnaniemi, W. M. 1913. Zur Kenntnis der Blattminierer speziell derjenigen Finnlands. I. Acta Soc. Fauna Fl. fenn. 37, no. 4. 137 pp.

Meijere, J. C. H. de. 1926. Die Larven der Agromyzinen (Fortsetzung und Schluss). Tijdschr. Ent. 69:227-317.

Meijere, J. C. H. de. 1938. Die Larven der Agromyzinen. Vierter Nachtrag. Tijdschr. Ent. 81:61-116.

Meijere, J. C. H. de. 1941. Die Larven der Agromyzinen. Sechster Nachtrag. Tijdschr. Ent. 84:13-30.

Nowakowski, J. T. 1964. Studien über Minierfliegen (Dipt. Agromyzidae). 9. Revision der Artengruppe *Agromyza reptans* Fall.-*A. rufipes* Meig. Dt. ent. Z. 11:175-213.

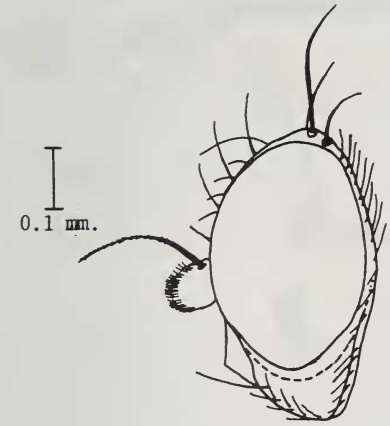
Sasakawa, M. 1956. A new species related to *Phytomyza saxifragae* Hering (Diptera, Agromyzidae). Insecta matsum. 19:105-108.

Sasakawa, M. 1961. A study of the Japanese Agromyzidae (Diptera). Part 2. Pacif. Insects 3:307-472.

Spencer, K. A. 1969. The Agromyzidae of Canada and Alaska. Mem. ent. Soc. Can. no. 64. 311 pp.

Tschirnhaus, M. von. 1969. Zur Kenntnis der Variabilität, Eidonomie und Verwandtschaft bemerkenswerter Agromyzidae (Diptera). Senckenberg. biol. 50:143-157.

Webb, D. A. 1964. Saxifragaceae. Flora eur. 1:364-381.



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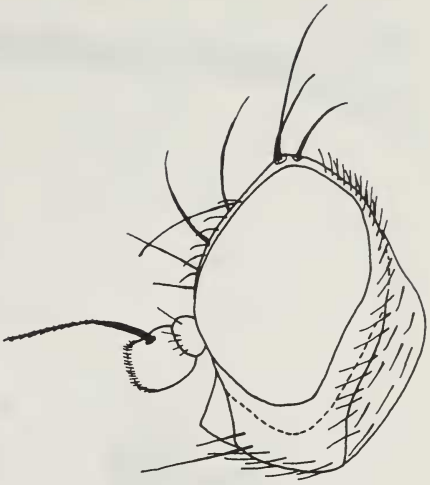

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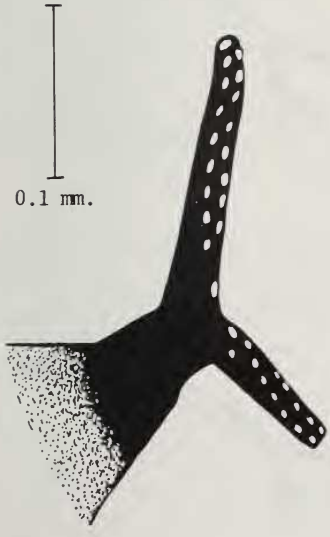

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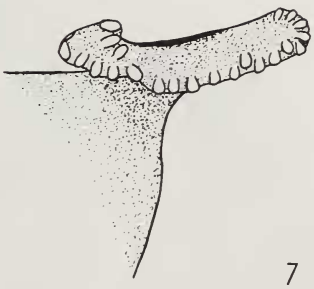

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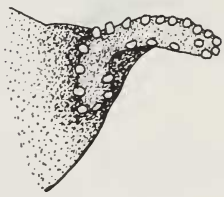

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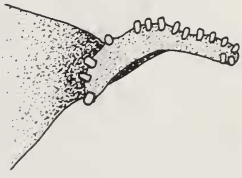

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Fig. 1. *Phytomyza mitellae* n. sp., head in left lateral view. Fig. 2. *Phytomyza deirdreae* n. sp., head in left lateral view. Fig. 3. *Phytomyza deirdreae* n. sp., posterior spiracles of puparium in left lateral view. Fig. 4. *Phytomyza aizoon* Hering, posterior spiracles of puparium in caudal view. Fig. 5. *Phytomyza saxifragae* Hering, posterior spiracles of puparium in left lateral view. Fig. 6. *Phytomyza tiarellae* n. sp., posterior spiracles of puparium (± dorsal view). Fig. 7. *Phytomyza mitellae* n. sp., posterior spiracles of puparium (± dorsal view).

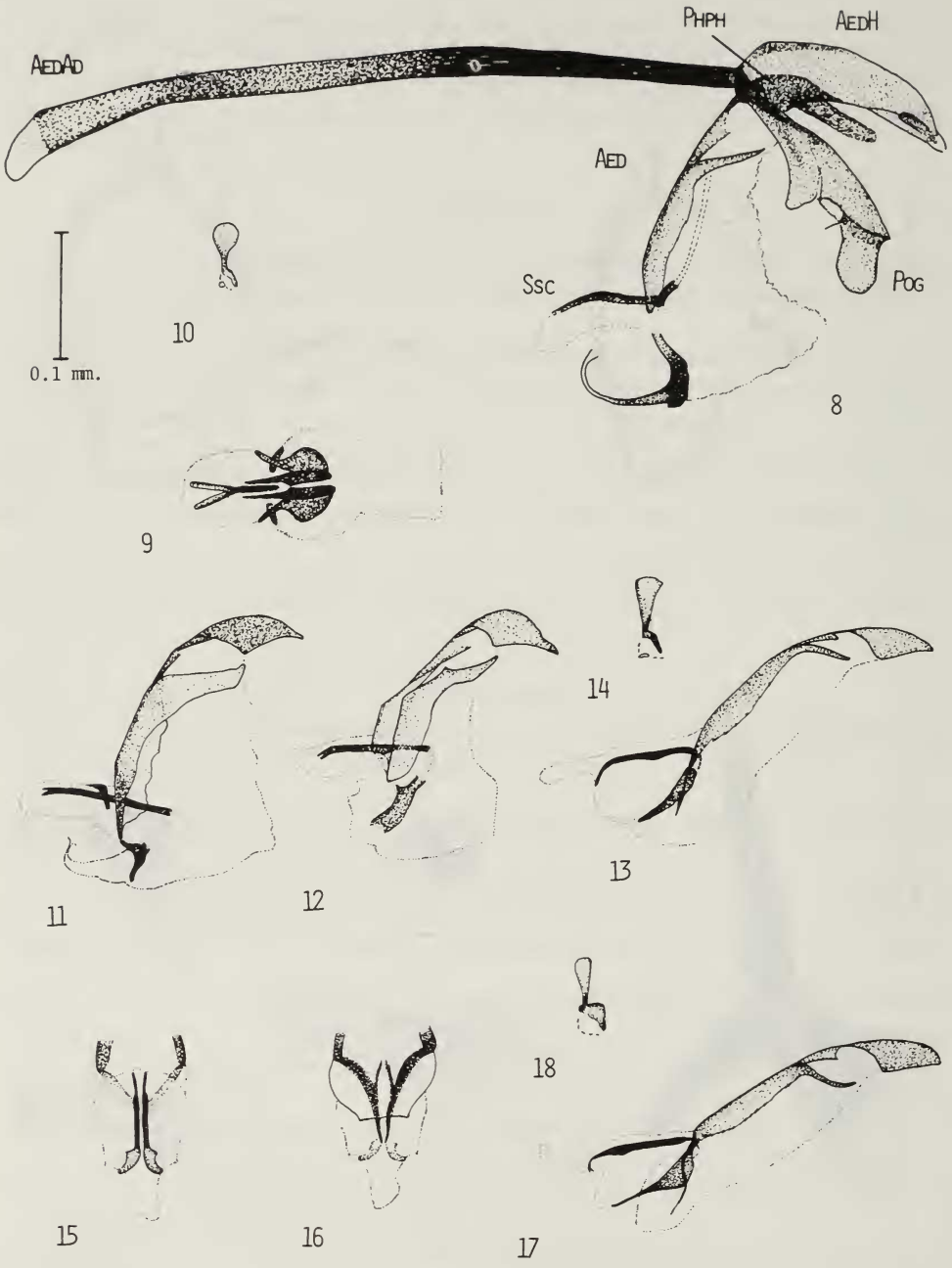
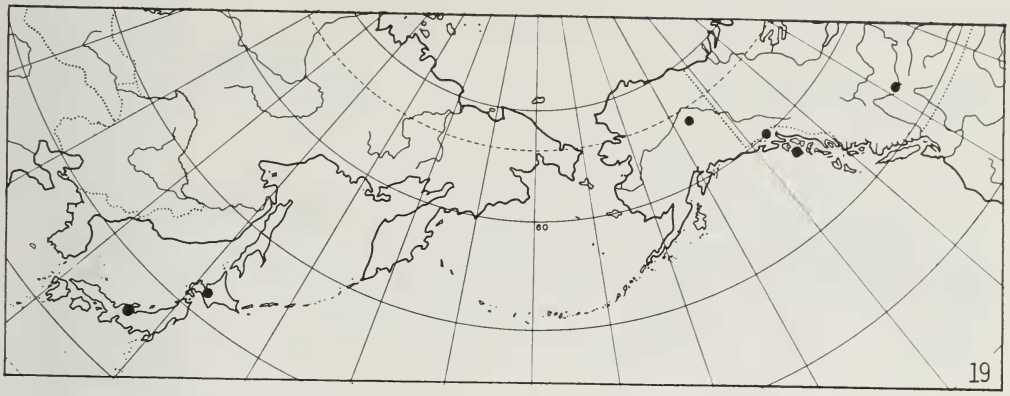
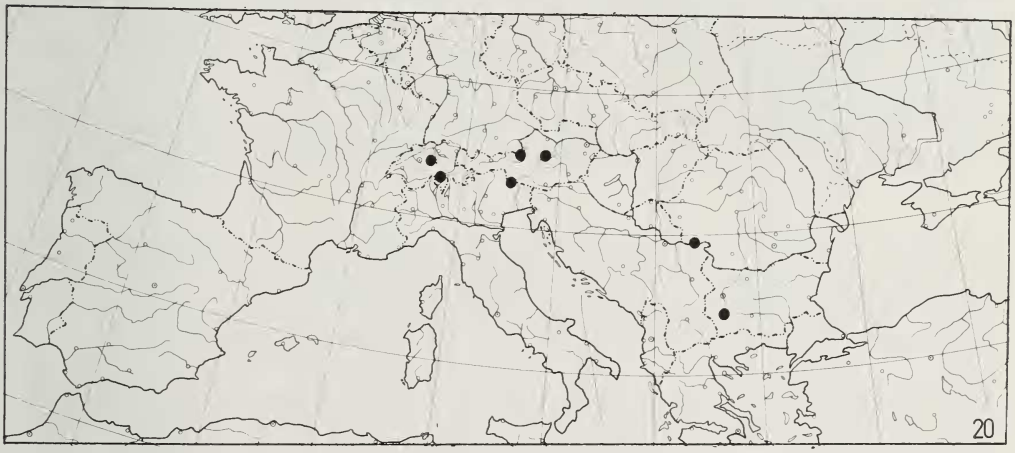


Fig. 8-10. *Phytomyza deirdreae* n. sp., holotype ♂: 8, aedeagus and associated structures in lateral view (AED aedeagus, AEDAD aedeagal apodeme, AEDH aedeagal hood, PHPH phallophore, POG postgonite, SSC supporting sclerite); 9, aedeagus in ventral view; 10, ejaculatory apodeme. Fig. 11. *Phytomyza saxifragae* Hering, Vals (Switzerland), aedeagus (♂) in lateral view. Fig. 12. *Phytomyza aizoon* Hering, paratype ♂, Mauthen (Austria), aedeagus in lateral view. Fig. 13-14. *Phytomyza mitellae* n. sp., holotype ♂: 13, aedeagus in lateral view; 14, ejaculatory apodeme. Fig. 15-18. *Phytomyza tiarellae* n. sp., holotype ♂: 15, distal section of aedeagus in dorsal view; 16, distal section of aedeagus in ventral view; 17, aedeagus in lateral view; 18, ejaculatory apodeme.





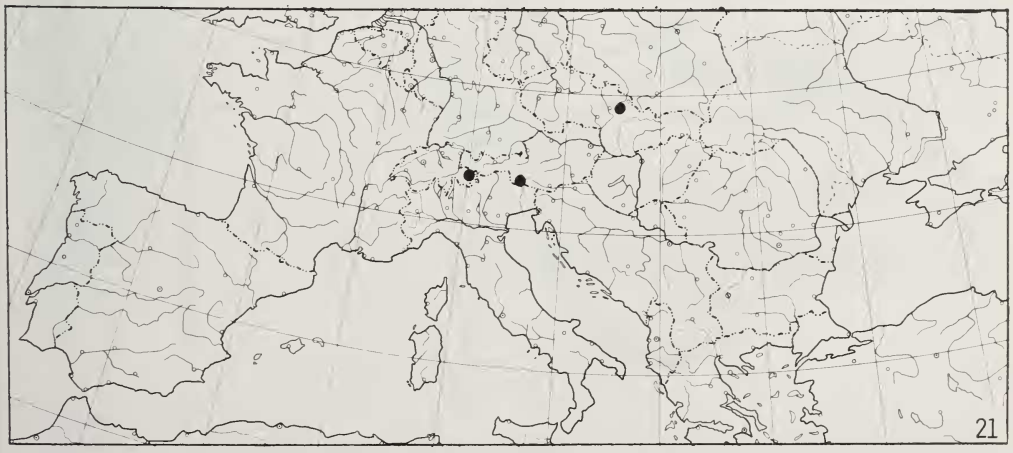
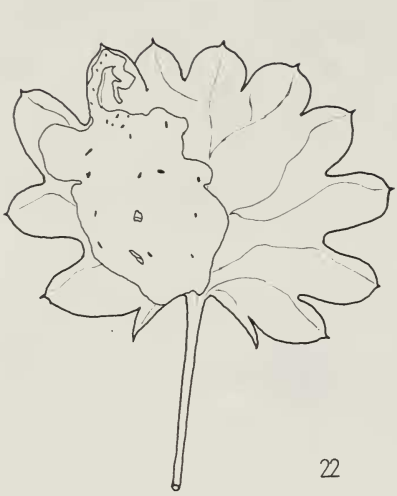


Fig. 19. Collection sites for *Phytomyza deirdreae* n. sp. Fig. 20. Collection sites for *Phytomyza saxifragae* Hering. Fig. 21. Collection sites for *Phytomyza aizoon* Hering.



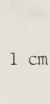


Fig. 22. Leaf-mine of *Phytomyza deirdreae* n. sp. on *Saxifraga punctata* L. Fig. 23. Leaf-mine of *Phytomyza saxifragae* Hering on *Saxifraga rotundifolia* L. (after Hering, 1927). Fig. 24. Leaf-mine of *Phytomyza tiarellae* n. sp. on *Tiarella trifoliata* L. Fig. 25. Leaf-mine of *Phytomyza mitellae* n. sp. on *Mitella nuda* L.